# Reducing False Alarms in the Intensive Care Unit: A Systematic Comparison of Four Algorithms

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The large percentage of false alarms in the Intensive Care Unit[1,2] (ICU) necessitates the development of improved data filter algorithms that provide more accurate alerts. A systematic comparison of the different effects of various filters on false versus true alarms can increase understanding and aid in algorithm development. Such a comparison has been performed on an actual ICU data set to explore the four filters: moving average, moving median, delay, and sampling rate.

**Methods.** Annotated ICU data[3] (i.e., ICU data in conjunction with notes of alarm soundings that occurred during the data collection time) along with recordings of monitor threshold limits were used. Each parameterized filter was compared to a standard threshold filter, which sounds an alarm as soon as a monitored value goes above the set upper limit or below the set lower limit. Moving average and moving median algorithms, respectively, calculate the mean or median of N values. The delay algorithm takes as input an integer, N, and only "sounds" an alarm when N sequential values have been above or N sequential values have been below the set thresholds. The sampling rate algorithm only allows one recorded value in every N values to be evaluated. Data processing involves: applications of filters to data, determination of alarm soundings, automated search for these soundings in the original annotations (made possible by first calculating a "window" around each alarm annotation), and creation of composite listings of results for each "windowsize" used.

**Results.** Data collected over a twelve-week period (35118 minutes) were analyzed. N values of 1 to 24, inclusive, 27, 30, 33, and 36 were tested. Filters that retain at least 90% of the clinically-relevant true alarms *that can be found by the standard threshold filter,* and which also eliminate the largest percentage of false alarms, are considered "closer to ideal." For example, a moving average over six values on electrocardiogram heart rate data retains 90% of clinically-relevant true alarms while eliminating 70% of the false alarms. (The full paper presents the results for each signal type.) Trends that exist within one kind of algorithm (e.g., moving average) as the value of N is varied can also be observed. For moving average and delay, there appear to be peak values (N=9 and N=6, respectively) at which the greatest difference exists between the percentages of true and false alarms that are affected. For moving median, trends indicate that true alarms are *lost* to a greater extent than false ones. No trend is apparent for sampling rate. Finally, altering windowsize (60, 90, and 120 seconds) does not appear to have any significant effect on the other results.

**Conclusions.** There is no question that high false alarm rates are less than desirable in the ICU. While none of the tested filters would be viable as a complete solution to developing improved alarm algorithms, the results of this study can direct attention to the single-signal filters that may or may not prove more effective when used in conjunction with other filter methods. Clearly, further exploration, especially of combinations of single-signal filters as well as of multi-signal filters, seems imperative for continued progress in the area of ICU patient monitoring.

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